Automation in Production System

Some elements of the firm's production system are likely to be automated, whereas others will be operated manually or clerically. For our purposes here, *automation* can be defined as a technology concerned with the application of mechanical, electronic, and computerbased systems to operate and control production.

The automated elements of the production system can be separated into two categories: (1) automation of the manufacturing systems in the factory and (2) computerization of the manufacturing support systems. In modern production systems, the two categories overlap to some extent, because the automated manufacturing systems operating on the factory floor are themselves often implemented by computer systems and connected to the computerized manufacturing support systems and management information system operating at the plant and enterprise levels. The term computerintegrated manufacturing is used to indicate this extensive use of computers in production systems.

1.Automated Manufacturing Systems

Automated manufacturing systems operate in the factory on the physical product.They perform operations such as processing, assembly, inspection, or material handling, in some cases accomplishing more than one of these operations in the same system.They are called automated because they perform their operations with a reduced level of human participation compared with the corresponding manual process. In some highly automated systems, there is virtually no human participation. Examples of automated manufacturing systems include:

- automated machine tools that process parts
- transfer lines that perform a series of machining operations
- automated assembly systems

- manufacturing systems that use industrial robots to perform processing or assembly operations
- automatic material handling and storage systems to integrate manufacturing operations
- automatic inspection systems for quality control

Automated manufacturing systems can be classified into three basic types (for our purposes in this introduction; we explore the topic of automation in greater depth in Chapter 3):

(1) fixed automation, (2) programmable automation, and (3) flexible automation.

Fixed Automation. Fixed automation is a system in which the sequence of processing (or assembly) operations is fixed by the equipment configuration. Each of the operations in the sequence is usually simple, involving perhaps a plain linear or rotational motion or an uncomplicated combination of the two; for example, the feeding of a rotating spindle. It is the integration and coordination of many such operations into one piece of equipment that makes the system complex. Typical features of fixed automation are:

- high initial investment for customengineered equipment
- high production rates
- relatively inflexible in accommodating product variety

The economic justification for fixed automation is found in products that are produced in very large quantities and at high production rates. The high initial cost of the equipment can be spread over a very large number of units, thus making the unit cost attractive com pared with alternative methods of production. Examples of fixed automation include machining transfer lines and automated assembly machines.

Programmable Automation. In *programmable automation*, the production equipment is designed with the capability to change the sequence of operations to accommodate different product configurations. The operation sequence is controlled by a *program*, which is a set of instructions coded so that they can be read and interpreted by the system. New programs can be prepared and entered into the equipment to produce new products. Some of the features that characterize programmable automation include:

- high investment in general purpose equipment
- lower production rates than fixed automation
- flexibility to deal with variations and changes in product configuration
- most suitable for batch production

Programmable automated production systems are used in low and mediumvolume production. The parts or products are typically made in batches. To produce each new batch of a different product, the system must be reprogrammed with the set of machine instructions that correspond to the new product. The physical setup of the machine must also be changed: Tools must be loaded, fixtures must be attached to the machine table, and the required machine settings must be entered. This changeover procedure takes time. Consequently, the typical cycle for a given product includes a period during which the setup and reprogramming takes place, followed by a period in which the batch is produced. Examples of programmable automation include numerically controlled (NC) machine tools, industrial robots, and programmable logic controllers.

Flexible Automation. Flexible automation is an extension of programmable automation. A flexible automated system is capable of producing a variety of parts (or products) with virtually no time lost for changeovers from one part style to the next. There is no lost production time while reprogramming the system and altering the physical setup (tooling, fixtures, machine settings). Consequently, the system can produce various combinations and schedules of parts or products instead of requiring that they be made in batches. What makes flexible automation

possible is that the differences between parts processed by the system are not significant. It is a case of soft variety, so that the amount of changeover required between styles is minimal. The features of flexible automation can be summarized as follows:

- high investment for a customengineered system
- continuous production of variable mixtures of products
- medium production rates
- flexibility to deal with product design variations

Examples of flexible automation are the flexible manufacturing systems for performing machining operations that date back to the late 1960s.

The relative positions of the three types of automation for different production volumes and product varieties are depicted in Figure 1.7. For low production quantities and new product introductions, manual production is competitive with programmable automation, as we indicate in the figure and discuss in Section 1.4.1.

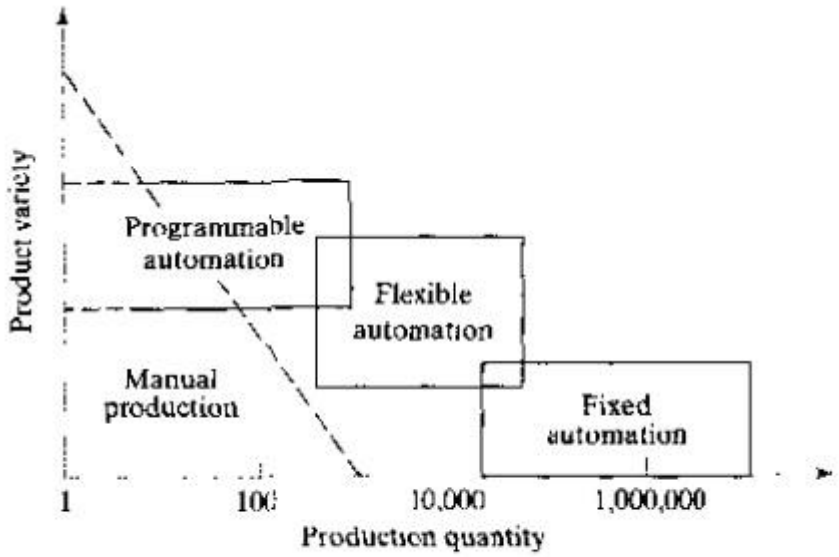

Figure 1.7 Three types of automation relative to production quantity and product variety.

2. Computerized Manufacturing Support Systems

Automation of the manufacturing support systems is aimed at reducing the amount of manual and clerical effort in product design, manufacturing planning and control, and the business functions of the firm. Nearly all modern manufacturing support systems are implemented using computer systems. Indeed, computer technology is used to implement automation of the manufacturing systems in the factory as well. The term *computer— integrated manufacturing*(CIM) denotes the pervasive use of computer systems to design the products, plan the production, control the operations, and perform the various business—related functions needed in a manufacturing firm. True CIM involves integrating all of these functions in one system that operates throughout the enterprise. Other terms are used to identify specific elements of the CIM system. For example, *computeraided design* (CAD) denotes the use of computer systems to support the product design function. *Computeraided manufacturing* (CAM) denotes the use of computer systems to perform functions related to manufacturing engineering, such as process planning and numerical control part programming. Some computer systems perform both CAD and CAM, and so the term *CAD/CAM* is used to indicate the integration of the two into one system. Computer—integrated manufacturing includes CAD/CAM, but it also includes the firm's business functions that are related to manufacturing.

Let us attempt to define the relationship between automation and CIM by developing a conceptual model of manufacturing. In a manufacturing firm, the physical production activities that take place in the factory can be distinguished from the information—processing activities, such as product design and production planning, that usually occur in an office environment. The physical activities include all of the processing, assembly, material handling, and inspection operations that are performed on the product in the factory. These operations come in direct contact with the product during manufacture. The relationship between the physical activities and the information—processing activities in our model is depicted in Figure 1.8. Raw materials flow into one end of the factory and finished products flow out the other end. The physical activities take place inside the factory. In our model, the information—processing activities form a ring that surrounds the factory, providing the data and knowledge required to successfully produce the product. These in

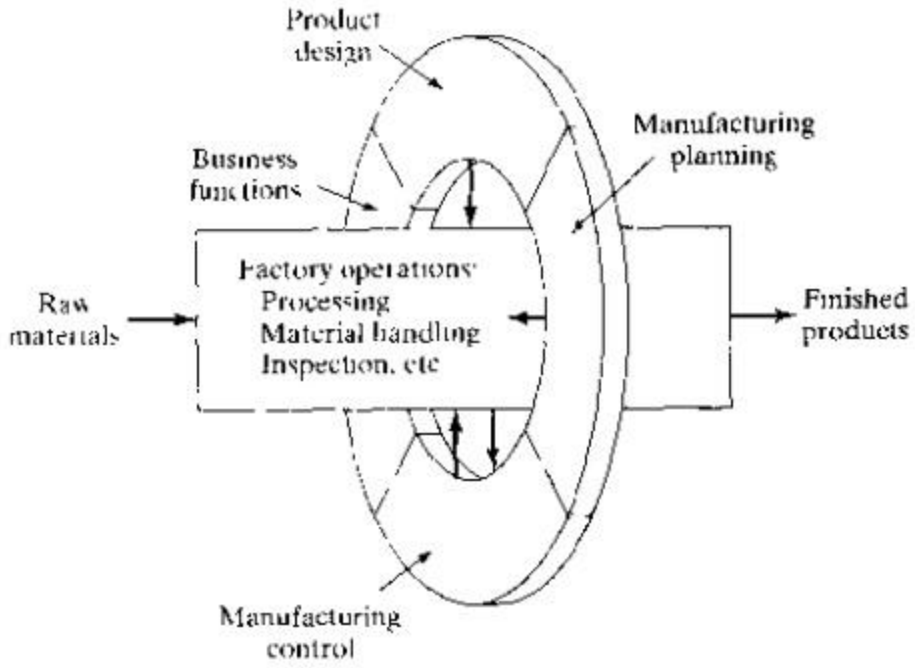

Figure 1.8 Model of manufacturing showing factory operations and the information-processing activities for manufacturing support.

formation—processing activities are accomplished to implement the four basic manufacturing support functions identified earlier: (1) business functions, (2) product design, (3) manufacturing planning, and (4) manufacturing control. These four functions form a cycle of events that must accompany the physical production activities but do not directly touch the product.

3. Reasons for Automating

Companies undertake projects in manufacturing automation and computerintegrated manufacturing for a variety of good reasons. Some of the reasons used to justify automation are the following:

1. *To increase labor productivity*. Automating a manufacturing operation usually increases production rate and labor productivity. This means greater output per hour of labor input.

2. *To reduce labor cost*. Everincreasing labor cost has been and continues to be the trend in the world's industrialized societies. Consequently, higher investment in automation has become economically justifiable to replace manual operations. Machines are increasingly being substituted for human labor to reduce unit product cost.

3. *To mitigate the effects of labor shortages*. There is a general shortage of labor in many advanced nations, and this has stimulated the development of automated operations as a substitute for labor.

4. *To reduce or eliminate routine manual and clerical tasks*. An argument can be put forth that there is social value in automating operations that are routine, boring, fatiguing, and possibly irksome. Automating such tasks serves a purpose of improving the general level of working conditions.

To improve worker safety. By automating a given operation and transferring the worker from active participation in the process to a supervisory role, the work is made safer. The safety and physical wellbeing of the worker has become a national objective with the enactment of the Occupational Safety and Health Act (OSHA) in 1970. This has provided an impetus for automation.

6. *To improve product quality*. Automation not only results in higher production rates than manual operations; it also performs the manufacturing process with greater uniformity and conformity to quality specifications. Reduction of fraction defect rate is one of the chief benefits of automation.

7. *To reduce manufacturing lead time*. Automation helps to reduce the elapsed time between customer order and product delivery, providing a competitive advantage to the manufacturer for future orders. By reducing manufacturing lead time, the manufacturer also reduces workinprocess inventory.

8. *To accomplish processes that cannot be done manually*. Certain operations cannot be accomplished without the aid of a machine. These processes have requirements for precision, miniaturization, or complexity of geometry, that cannot be achieved manually. Examples include certain integrated circuit fabrication operations, rapid prototyping processes based on computer graphics (CAD) models, and the machining of complex, mathematically defined surfaces using computer numerical control. These processes can only be realized by computer controlled systems.

9. *To avoid the high cost of not automating*. There is a significant competitive advantage gained in automating a manufacturing plant. The advantage cannot easily be demonstrated on a company's project authorization form. The benefits of automation often show up in unexpected and intangible ways, such as in improved quality, higher sales, better labor relations, and better company image. Companies that do not automate are likely to find themselves at a competitive disadvantage with their customers, their employees, and the general public.

Automation Advantages

- Reduction in production time – having a machine that is automated definitely speeds up the production time since no thinking is needed by the machine, there is better repeatability, and less human error.

- Increase in accuracy and repeatability – when an automated machine is programmed to perform a task over and over again, the accuracy and repeatability compared to an employee is far greater.
- Less human error – no one is perfect, and we are all prone to making mistakes. Which is why a machine that performs repeated tasks is less likely to make mistakes than an employee.
- Less employee costs – by adding automated machines to an operation, means less employees are needed to get the job done. It also indicates less safety issues, which leads to financial savings. With having less employees, there are numerous costs that are diminished or reduced such as payroll, benefits, sick days, etcetera.
- Increased safety – having automated machines means having less employees who perform tasks that can be dangerous and prone to injury, which can make the work environment safer.
- Higher volume production – investing in automated equipment creates a valuable resource for large production volumes, which in turn, will increase profitability.

Automation Disadvantages

- Less versatility – by having a machine that can perform a certain task limits to the flexibility and variety of tasks that an employee could do.
- More pollution – different types of machines operate using motor which may require gases or chemicals in order to operate. This can cause an increase in pollution in the workplace.
- Large initial investment – automated machines can be one of the most costly operating costs for a company. With automated machines running anywhere between thousands and millions of dollars depending on the type and degree of automation.
- Increase in unemployment – by increasing the amount of automation, there are less employees required causing high unemployment rates.
- Unpredictable costs – there can be several unpredictable costs that may exceed the actual cost saved by the automation itself. Some of these costs could include research and development costs of automating a process, preventative maintenance costs, and the cost of training employees to operate automated machines.